Turbidity or Not Turbidity

Activity Description
Students learn how storm water can carry sediment into clean lakes and ponds that can lead to high turbidity. Students will learn how scientists and volunteers measure the clarity of water in a pond or lake.

Take Home Message
In order to protect the water quality of our lakes and ponds, it is important to prevent erosion along shorelines. Citizen volunteers can help monitor the conditions of ponds by taking measurements of the transparency of ponds.

Massachusetts Frameworks
Technology/Engineering

Engineering Design and Use #3

Materials
- Three Clear Plastic Jars- Mayonnaise Size or Larger
- Three Clear Plastic 1000 ml Graduated Cylinders
- One small diameter Secchi disc with bamboo pole, marked every inch.
- Plastic Aquatic Plants, gravel, macaroni
- Small Bag of Potting Soil
- Corn Starch
- Green Sugar Crystals
- Luau Table Skirt – mounted on a piece of foam board to cover fronts of cylinders
- Plastic or paper boat or canoe that sits on the top of the board.
- Map of Cape Cod Lakes and Ponds
- Clean water supply to fill jars and cylinders

Set-Up
Place the three plastic jars on the table, filled to the top with water. Place gravel in the bottom, "plant" a fake plant in each. Have macaroni, dirt, and starch in baggies -available for the activity.

Fill the three plastic graduated cylinders with water to the top. The first cylinder will remain clear. Add one tablespoon potting soil and a small amount (less than 1/8 teaspoon) corn starch to the second cylinder, mix well- the Secchi disc should remain visible about half way down the cylinder. Add ten or so shakes of sugar to the third in addition to 1/8 teaspoon corn starch, mix until dissolved- the sugar mixture should be strong enough so that the Secchi disc disappears about 2-3 inches down in the cylinder: the sugar simulates an algal bloom effect. Prop the foam board across the front of the three cylinders to simulate a pond cross-section. Attach the boat to the top on the "pond's" surface.

Background Vocabulary
Algae- Aquatic plants that can grow as single tiny cells (microscopic) or as long strands
Eutrophication- the natural physical, chemical, and biological changes that take place as nutrients, organic matter, and sediment are added to a lake. When accelerated by human-caused influence, this process is called cultural eutrophication
Monitoring- to watch, observe, and check conditions
Nutrient- something that nourishes or promotes growth
Sediment - material or matter that has settled to the bottom of a lake or pond
Erosion- removal of soil through the processes of wind, water, or physical disturbance
Surface water- water that is above the land's surface
Turbidity- the measure of water clarity, or how much light can pass through water, sometimes called transparency

Background Science

(background material adapted from Project WET and MWRA curriculum)

Flowing water has a tremendous capacity to carry material, often for a long distance. Sediment or soil particles that have been carried into a waterway by water running off the land are a significant contributor to water pollution. They are a major component of nonpoint source pollution, the most common form of water pollution in the US. When soil particles are eroded into a waterway as sediment, the muddy water that results can have many harmful impacts. It can smother fish eggs and aquatic insects on the bottom, scrape fish gills, block sunlight and slow the growth of plants, and even clog clams and oysters as they filter water through their bodies. Turbidity can also raise water temperatures because the suspended particles absorb the sun's heat. Soil erosion also contributes nutrients to the surface water.

Turbidity is a measure of the clarity of water, or the amount of light that can penetrate it, and is directly affected by the amount of sediment that runs off into a waterway. Turbidity, transparency and sediment are related. The more sediment that runs off of the land into the water, the higher the turbidity, and the lower the transparency. **What are some factors that affect the turbidity of water? Erosion of soil from the land is a major contributor to the turbidity of water and this erosion can come from two categories, natural and man-made.**

Weather and seasons are natural causes that can contribute to turbidity. Natural erosion of soil happens as a result of heavy rains, spring snow melt or storm surges by stirring up soils and sediments, increasing turbidity. **Other natural factors that increase turbidity include growth of algae and zooplankton populations.** Water that may be clear in the spring may grow turbid by August because of plant growth enhanced by warmer days and longer sunlight hours. **Human-caused erosion results from road-building, construction, agriculture and other activities that remove vegetation from the land surface. Even people walking along steep shoreline paths can cause soil erosion by trampling vegetation. In many cases, human-caused erosion can be managed or prevented to reduce erosion and lower the turbidity of the adjacent waterways.**

Vegetation holds the soil in place, and also slows the flow of water, allowing soil particles to settle out of the water. Governments have established recommendations to leave **vegetation buffer strips**: plants along a waterway that separate open fields or yards from the water. The strips of vegetation buffer the impact of sediments entering the waterway by slowing down the water as it runs over the land, allowing sediment to settle out around the plants. When water flow is slowed down, particles of sediment settle out. The largest and heaviest particles settle out first, such as rocks and pebbles. Sand-sized particles settle out next, while the smaller particles, such as clay and silt, settle out last. Vegetative strips also block the flow of nutrients that are present in the sediment by trapping them in the roots of the plants. Nutrients primarily enter ponds from groundwater sources (i.e. nutrient-rich septic system effluent), but sediments also contribute organic matter, serve as breeding grounds for pathogenic materials, and accelerate the process of eutrophication.

Scientists and citizen volunteers help monitor the health of Cape Cod lakes and ponds by measuring the transparency each year. This is accomplished by lowering and raising a plastic disc, called a Secchi disc, into the water column and by observing the depth at which the disc disappears from sight. The depth is called the "Secchi depth". There are several other methods to measure turbidity including the use of a *nephelometer*- that electronically measures the amount of light scattered by the suspended particles in the sample, reporting the results in Nephelometric Turbidity Units (NTU's) (*Nephele* is the Greek work for "cloud", *metric* means "measure". *Nephelometric*, therefore, means "measuring cloudiness.")- we don't have one of those, so we are going to simulate the measurement with mini Secchi discs. We can also measure turbidity with small vials of the sample water, holding them over a chart with circles of varying shades of grey. This technique is similar to the reporting technique using Jackson Turbidity Units. The vials and charts will be available if you want to try a second method of measuring, and comparing to the Secchi method. (*This last bit is pretty advanced for elementary school students, and while it's good background info to have, should probably not be covered with them, especially since we don't even have that instrument*)

Activity Procedure/Script

- **Introduce yourself to the students. Tell them that we are going to learn about what the word "Turbidity" means, and why it's important to know what this is so we can keep our lakes and ponds healthy.**

- **Ask them to look at the map of Cape Cod lakes and ponds. See if they can name some of the lakes, or where their favorite ones are.** (*The map is probably not necessary. If it's available, it can be used, but just asking the students to mention some of their favorite ponds or lakes is enough and helps them.)*
    - They may need help finding their town, so you can point out some of them.
    - (Whether or not you use the map) Encourage them to talk about what they like to do there, swim, fish, boat, etc.
    - Point out how enjoyable it is to swim in nice clear, clean water, where you can see all the way to the bottom, or see your friends when you duck under the water.
- **Ask if any of the students know what the word erosion means.**
    - Explain to the students that erosion is when soil is removed by wind, water or physical disturbance.
    - Tell them that erosion happens naturally, but that human activities often speed it up.
    - Explain that erosion can cause soil and sediments to travel into the lakes and ponds.
- **Ask them if they can think of examples of how this might happen.**
    - Examples include hard rain storms, ocean storms, road or house construction, and foot paths along shorelines.
- **Ask the students why the sediments might create problems for water quality in the lake**
    - You want to hear things like make the water murky, make you not want to swim in it.
    - Explain that sediment in the water reduces the natural clarity of the water, or how much light can pass through the water.
- **Show the students the three jars of clean water standing on the table.** (*Previous members advise that this is not necessary, and there is probably not enough time to do all of this, but if you want to try it, it could be something different and fun.)*
    - Explain that these are examples of water from three different lakes.
    - Have them observe that the fake plant is clearly visible and the bottom is nice and clean for the fishes to lay eggs and party. Have them toss a few macaroni in each jar to simulate the fish.
    - Explain that we are going to add some soil to one jar to see how that might affect the fish.
    - Have a volunteer add some dirt into the second jar, and stir it around with a bamboo stick.

- **Ask the students what they think happens to the fish when they have to swim in the sediment-laden water**
    - They may say it is hard for the fish to see.
    - You can also explain that the sediment can clog the gills of the fish, or even tear out the gills of newly born fish. It can smother their eggs, or block sunlight making it hard for plants to grow.
    - Have a volunteer add the sugar/starch mix into the third jar, and stir it around with a bamboo stick.

- **Ask the students what might have caused the water to become so highly colored.**
    - Explain that sediment also contributes organic matter and nutrients to the water, and raises the temperature as the sunlight is absorbed in the particulate matter.
    - The nutrient soup cooks, and algae begin to grow. The third jar is a simulation of an algal bloom.
    - Talk with the students about the consequences of the algal bloom. The plants grow rapidly and then die. The dying plants use up oxygen as they decay and there is none left for the fish. This is called eutrophication. (Definitely feel free to reference The Good, the Bad, the Algae at this point if they've already been there, as it talks a lot about this stuff)
- **Sum up the appearance of the water in the three jars. Ask which jar sunlight would pass through the most easily. Why do the organisms in the jars need the sunlight?**
- **Ask the students to list some ways to help keep sediment out of the lakes and ponds and keep the water clean.**
    - Make sure they know they should always stick to established trails around ponds. You might also mention that motor boats and jet skis can stir up water and reduce transparency.
    - **What else can they do? Encourage parents to keep buffer strips around ponds, minimize use of fertilizers, and picking up dog poop especially around water bodies.** (This part is very important to mention.)
- **Explain to the students that here on Cape Cod we monitor the transparency of our lakes and ponds by using something called a Secchi Disc, and that we are going to do that today to see how it is done. It is important to monitor the lakes and ponds to make sure that the water quality is good, and that the water is healthy for the plants and animals**
    - Let each student take a turn using the Secchi disc. Pull the disc up all the way to the top of the graduated cylinder, then by looking down onto the tops of the cylinders watch until the disc disappears. Have the student measure how many inches deep this is, and write down the observation. Let them go to the second and third stations as a comparison, writing down the depth at each station. Let each student take a turn.
    - Record the group readings, comment on variations in the results, and the reasons why there may be differences in the results. (material settling, light in the room changes, bad eye sight, mistake on reading stick) .
- **If there is extra time you can repeat the transparency monitoring using the Jackson Turbidity Method.** (You probably won't have time for this, but if you want to give it a shot you can.)
    - Hint: Make up vials with differing transparencies in the small vials using different solutions of corn starch, which will stay in suspension longer than dirt.

Clean-Up

During the festival

- After each group, dump out the smaller jars and refill them with clean water, replace the gravel and plants. You can recycle the macaroni if it doesn't get too soggy.
- If using the small vials, cap them for storage, agitate well before each use.

After the festival

- Thoroughly rinse out and dry jars and cylinders.
- Dispose of dirty water and any wet macaroni by straining through a sieve first, or dumping out on the lawn, picking out the macaroni, and putting them in the trash.
- Repack dirt and dry macaroni in securely sealed baggies.
- Repack everything into the Rubbermaid container marked TURBIDITY OR NOT TURBIDITY.